My NASA Data

6-8: Seasonal Science: Building Claims from Evidence Lesson Plan

Purpose**:** Students will analyze surface temperature and solar radiation data to construct explanations about the relationship of seasons and temperature to the amount of solar energy received on Earth's surface. By observing the graphs of these variables collected from three cities: Porto Alegre, Brazil, Quito, Ecuador, and Memphis, TN, students will construct claims about the seasons by using scientific evidence and reasoning.

Grade Level: 6-8 **Time:** 3-45 minute class periods	**Lesson Objectives:** - Students will practice the process of making claims, collecting evidence to support claims, and applying scientific reasoning to connect evidence to claims. - Students will analyze surface temperature and solar radiation data to construct explanations about the relationship of seasons and temperature to the amount of solar energy received on Earth's surface at three United States cities: Porto Alegre, Brazil, Quito, Ecuador, and Memphis, TN. - By observing the graphs of these variables, students will construct claims about the seasons by using scientific evidence and reasoning and will use these to justify their argument.	**Sphere(s):** ● Atmosphere

Phenomena NASA Connection:

The natural phenomenon of seasons is a predictable event that never ceases to amaze many with the changes of fauna and flora that it brings. But why is it that when the Earth is closest to the sun, the Northern Hemisphere has winter? And when they are farthest from the sun, they have summer? This phenomenon occurs because of Earth's tilt, which causes the seasons to occur and thus the climate of that region.

NASA scientists use data from multiple satellites to analyze data to answer questions related to Earth's axial tilt and seasonal change. GLOBE and My NASA Data enable educators and students to connect with NASA scientists and access the satellite data to answer these questions using solar radiation and surface temperature data. In this lesson, Seasonal Science: Building Claims from Evidence, students will observe patterns of monthly solar radiation and compare these values to average monthly temperatures. Students will make a claim as to how these two variables are related and collect evidence to justify their claims.

Essential Questions:

1. What role does Earth's axial tilt have in the flow of energy through the Earth System?
2. How are surface temperature and solar radiation related?
3. What role does argumentation have in science?

NGSS Performance Expectation(s):

- Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. (MS-LS1-1)
- Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon. (MS-LS1-3)
- Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-PS2-4)
- Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)

Science & Engineering Practices: **Engaging in Argument from Evidence** ▪Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **Asking Questions and Defining Problems** Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. --- **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**Disciplinary Core Ideas**: n/a	**Crosscutting Concepts**: **Cause and Effect** ▪ Cause and effect relationships may be used to predict phenomena in natural or designed systems. --- **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** Science findings are limited to questions that can be answered with empirical evidence.

NCTM Math Standards: n/a

Cross-Curricular Connections:

National Geography Standards:

-How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

Common Core State Standards ELA Standards:

- CCSS.ELA-LITERACY.RI.6.7
  Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
- CCSS.ELA-LITERACY.RI.6.8
  Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.
- CCSS.ELA-LITERACY.RI.7.8
  Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims.
- CCSS.ELA-LITERACY.RI.8.8
  Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.

Career Connections:

- **Atmospheric and Space Scientists** – Investigate weather and climate related phenomena to prepare weather and climate related phenomena to prepare weather reports and forecasts for the public
- **Computer and Information Scientists** – Conduct research in the field of computer and information science
- **Cartographers and Photogrammetrists** – Collect, analyze, and interpret geographic data in creation of maps

Multimedia Resources:

- Teacher Resource Page: Seeing Equinoxes and Solstices from Space
- Video: Seeing Equinoxes and Solstices from Space, https://youtu.be/FmCJqykN2J0
- Video: Why Do We Have Different Seasons? | California Academy of Sciences

https://youtu.be/WgHmqv_-UbQ
- Video: NASA: Why does the Sun Matter for Earth's Energy Budget?, https://youtu.be/82jE-yvB8xU
- Video: Net Radiation
- Optional: Eyes on the Earth (NASA App) - must be downloaded in advance
- Optional: The University of Nebraska's Seasons Simulator (Flash Required)

Materials/Resources Needed:

Per Student:
- Post-it Notes
- Marker
- Fisherman Observation Sheet
- Student Data Sheet 1
- C-E-R Rubric

Per Group of 2 Students:
- Student Sheet A, B, C

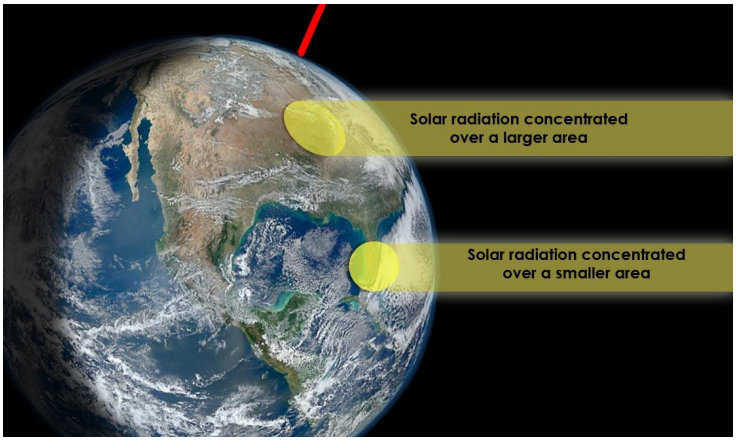
Per Class:
- Inflatable Globe (Optional)
- Flashlight (Optional)

Key Vocabulary:

axial tilt
claim
dependent variable
evidence
flux
independent variable
insolation
latitudes
net radiation
qualitative observation
quantitative observation
reasoning
solar radiation
temperature
thermal radiation

Background Information:

Earth's seasons are caused by a shift of sunlight—which is controlled by Earth's orbit around the Sun and the tilt of the Earth as it rotates on its axis. The 23.5 degree tilt of the Earth's axis results in changes of the angle of incident sunlight.



The angle of incoming **solar radiation** influences seasonal temperatures of locations at different latitudes. When the sun's rays strike Earth's surface near the equator, the incoming solar radiation is more direct (nearly perpendicular or closer to a 90˚ angle). Therefore, the solar radiation is concentrated over a smaller surface area, causing warmer temperatures. At higher latitudes, the angle of solar radiation is smaller, causing energy to be spread over a larger area of the surface and cooler temperatures. Because the angle of radiation varies depending on the latitude, surface temperatures on average are warmer at lower latitudes and cooler at higher latitudes (even though higher latitudes have more hours of daylight during the summer months).

Every day, Sun's energy enters the Earth system when sunlight penetrates the top of the atmosphere. Energy goes out in two ways: 1. reflection by clouds, aerosols, or the Earth's surface; and 2. thermal radiation—heat emitted by the surface and the atmosphere, including clouds. The rest of the light is absorbed by the atmosphere, land surfaces and oceans, and this absorption keeps Earth warm. The difference between how much solar energy enters the Earth system and how much heat energy escapes into space is called "net radiation," sometimes called net flux; it is the balance between incoming and outgoing energy at the top of the atmosphere. Some places absorb more energy than they give off back to space, so they have an energy surplus. Other places lose more energy to space than they absorb, so they have an energy deficit. Net radiation is the total energy that is available to influence the climate. The global average net radiation must be close to zero over the span of a year or else the average temperature will rise or fall.

To learn more about the Earth's Energy Budget, visit - Https://youtu.be/82jE-yvB8xU

Prerequisite Student Knowledge:

- Basic ability to read a map
- Understanding of latitude and longitude
- Energy Transfer
- Revolution and orbit (Earth travels around the Sun)

Possible Misconceptions:

- A common misconception among students is that the seasons are caused by the distance between the Earth and Sun. In fact, summer in the Northern Hemisphere occurs at aphelion, the farthest distance between the Earth and Sun, and follows summer solstice when incident sunlight is most concentrated along the Tropic of Cancer, 23 degrees 26 minutes 22 seconds.

Materials/Resources Needed:

Per Student:

- Post-it Notes
- Marker
- KWL+? Chart
- Student Data Sheet 1
- C-E-R Rubric

Per Group of 2 Students:

- Student Sheet A, B, C

Per Class:

- Inflatable Globe (Optional)
- Flashlight (Optional)

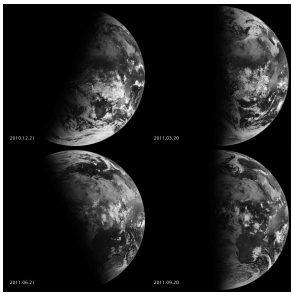
Multimedia Resources:

- Teacher Resource Page: Seeing Equinoxes and Solstices from Space
- Video: Seeing Equinoxes and Solstices from Space, https://youtu.be/FmCJqykN2J0
- Video: Why Do We Have Different Seasons? | California Academy of Sciences https://youtu.be/WgHmqv_-UbQ
- Video: NASA: Why does the Sun Matter for Earth's Energy Budget?, https://youtu.be/82jE-yvB8xU
- Video: Net Radiation
- Optional: Eyes on the Earth (NASA App) - must be downloaded in advance
- Optional: The University of Nebraska's Seasons Simulator (Flash Required)

Procedure:

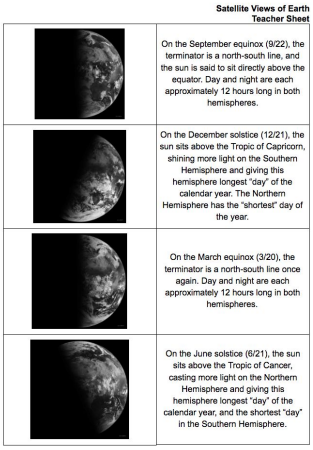
Part 1: Exploring Sunlight

1. Set the stage for learning by telling students that they will observe NASA images and data to construct claims about the seasons. They will be expected to use scientific evidence and reasoning to make a claim about the phenomenon of seasons.
2. Tell students that they will observe a video of the Earth taken by a satellite over the period of one year. Ask students to imagine that they were a videographer standing on the Moon collecting video footage for an entire year. Students should brainstorm what changes they would see over the course of a year.
3. Distribute the KWL+? Chart. Students should write the term "Sunlight" in the **K** (What do you *think you* know? What do you *think* you would see?) column and write out their ideas.



K	W	L	+?
What do you *think you* know? What do you *think* you will see?	What do you WANT to learn? What questions do you have?	What did you LEARN?	What scientific QUESTIONS do you have? Include independent and dependent variables.

4. Display Teacher Resource: "Seeing Equinoxes and Solstices from Space". Explain to students that these images show evidence of Sunlight on Earth's surface throughout the year. Ask students to generate questions that they want to explore and write these under the W column (What do you WANT to learn? What questions do you have?).
5. Run the video, "Seeing Equinoxes and Solstices from Space" https://youtu.be/FmCJqykN2J0. As the video runs, students should return to the KWL and document their observations in the **L** column.
6. Ask students to describe their observations. What did you observe? What changes did you notice? Is this movement cyclical? If students struggle to observe the changes, review the key talking points on "Satellite Views of Earth" Teacher Sheet.
7. Draw students' attention to the terminal at four times through the year by identifying the African continent. How does Africa change over time? A possible idea about the African continent includes the line where light and dark meet (terminal) seems to move over the year. Students may also note the date and time running on the left side.
8. Optional: Model this using a flashlight and globe and allow students to replicate the process of the Earth moving through four seasons with the axial tilt. Have students attempt to replicate the images on the screen with the globe and light.
9. Next have students brainstorm scientific questions related to this phenomenon. Students should be sure to include an independent and dependent variable. These could include things like: how do temperatures (responding) change over time (manipulated), how is the terminal line (manipulated) related to plant growth (responding), etc. Add these to the ***+? column.***

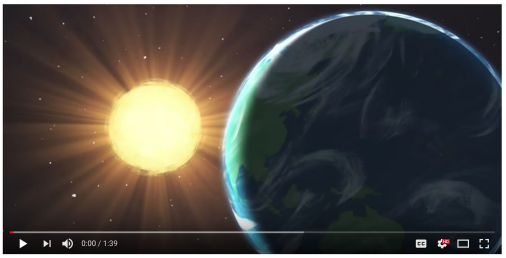


Exploring Solar Radiation

1. Introduce another scientific variable, solar radiation, which is the primary source of energy to the Earth. Tell students that they will observe a video that shows monthly radiation received on Earth from the Sun.
2. Direct students to return to the KWL+? chart's K and L column. Students should draw a line under the previous section to write their answers and write the term "Solar Radiation".

K	W	L	+?
What do you *think you* know? What do you *think* you will see?	What do you WANT to learn? What questions do you have?	What did you LEARN?	What scientific QUESTIONS do you have? Include independent and dependent variables.

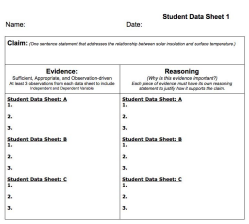
3. Direct students to document their observations in the **L** column as the video runs. View the video *NASA: Why does the Sun Matter for Earth's Energy Budget?* (1 min, 39 sec) https://youtu.be/82jE-yvB8xU
4. Ask students to brainstorm new scientific questions that come to mind now that they better understand solar radiation. Add these to the ***+? column.***
5. Introduce solar insolation with students.
6. Now show the animation of Earth's net radiation as observed by the NASA CERES instrument during 2006 – 2013 (17 secs). (Be sure to show at full screen so the date is clearly visible.) Point out the date at the bottom and the legend. Describe that the colors represent the



NASA: Why does the Sun Matter for Earth's Energy Budget?

kilowatt-hours of sunlight falling on every square meter of the surface per day (Watts/m2), averaged over one month.

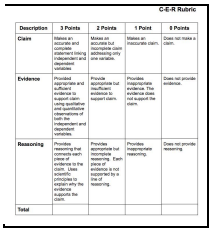
7. Ask students to predict the changes that they will likely see (e.g., when will we expect to see more orange in the N. Hemisphere vs. S. Hemisphere? Vice Versa. When will we expect to see the hemisphere's balanced with respect to radiation?, etc.)
8. Distribute Student Data Sheet 1 and the C-E-R Rubric and review with students.
9. Direct students to make a claim about the relationship of the seasons with the amount of solar radiation received on Earth and write this at the top of the sheet under "Claim".


Student Data Sheet 1

Name: Date:

Claim: *(One sentence statement that addresses the relationship between solar insolation and surface temperature.)*

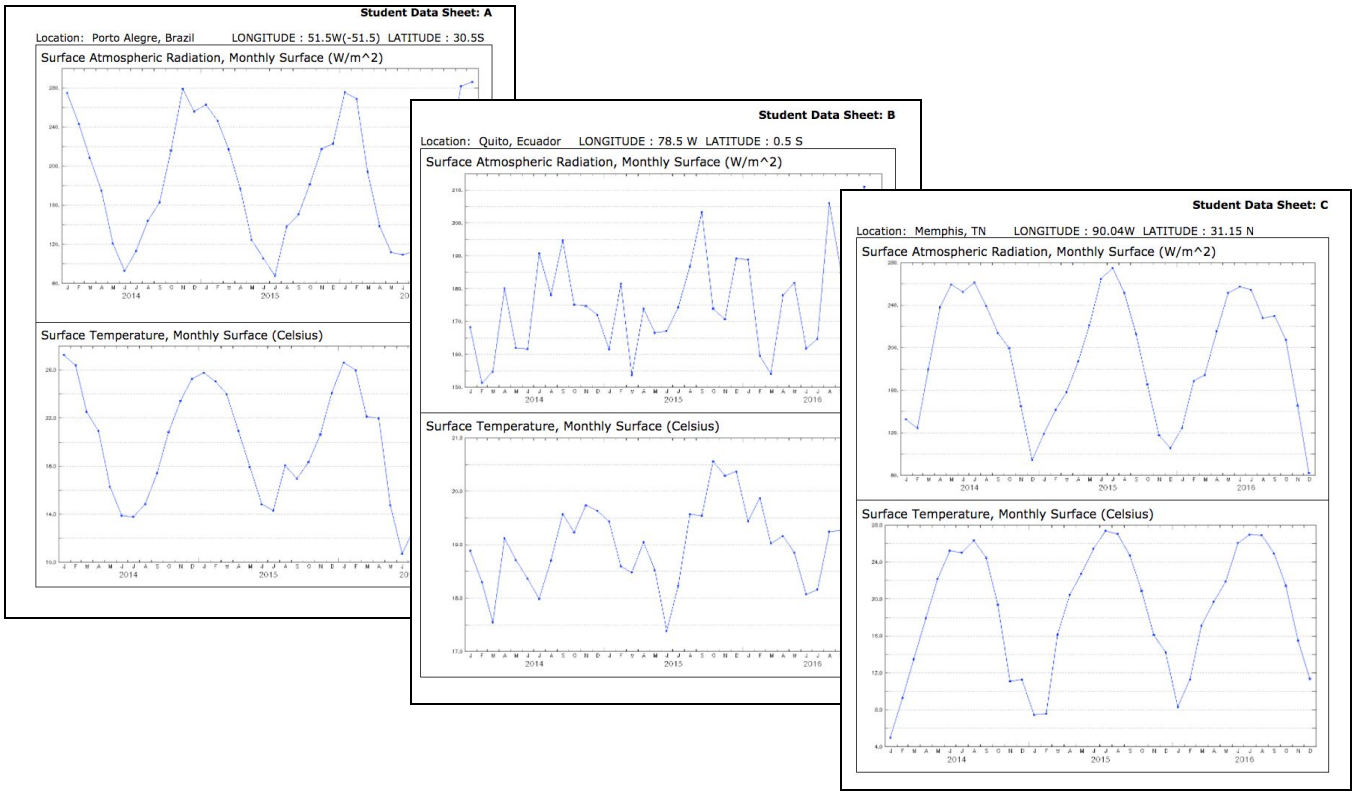
Evidence: Sufficient, Appropriate, and Observation-driven: *At least 3 observations from each data sheet to include Dependent and Dependent Variable*	**Reasoning** *(Why is this evidence important?) Each piece of evidence must have its own reasoning statement to justify how it supports the claim.*
Student Data Sheet: A 1. 2. 3.	**Student Data Sheet: A** 1. 2. 3.
Student Data Sheet: B 1. 2. 3.	**Student Data Sheet: B** 1. 2. 3.
Student Data Sheet: C 1. 2. 3.	**Student Data Sheet: C** 1. 2. 3.


C-E-R Rubric

Description	3 Points	2 Points	1 Point	0 Points
Claim	Makes an accurate and complete claim describing independent and dependent variables	Makes an accurate but incomplete claim and/or describing only one variable.	Makes an inaccurate claim.	Does not make a claim
Evidence	Provided appropriate and sufficient evidence to support claim using qualitative and quantitative observations of both the independent and dependent variables.	Provide appropriate but insufficient evidence to support claim.	Provides inappropriate evidence. The evidence does not support the claim.	Does not provide evidence.
Reasoning	Provides reasoning that connects each piece of evidence to the claim. Uses scientific principles to explain why the evidence supports the claim.	Provides appropriate but incomplete reasoning. Each piece of evidence is not supported by a piece of reasoning.	Provides inappropriate reasoning.	Does not provide reasoning
Total				

Part 3: Analyzing Evidence to Support Claim about the Seasons

1. Distribute the Student Data Sheet A (Porto Alegre, Brazil) to student groups. Students will work in teams of two to make observations about the monthly surface temperature and monthly solar insolation values at Porto Alegre, Brazil over a three year period (2014, 2015, and 2016).
2. Students will document at least three lines of evidence (qualitative and quantitative observations). Students will also connect each line of evidence to their claim in the Reasoning column. Here, they should include scientific principles that support their claim for each line of evidence.
3. Repeat Steps 1 and 2 for Quito, Ecuador (Student Sheet B) and Memphis, TN (Student Sheet C).
4. Evaluate student work with the C-E-R Rubric. Review the work as a class.



Student Name: **Date:** **Period:**

K	W	L	+?
What do you *think you* know? What do you *think* you would see?	What do you WANT to learn? What questions do you have?	What did you LEARN?	What scientific QUESTIONS do you have? Include independent and dependent variables.

Student Name: Date: Period:

C-E-R Rubric

Description	3 Points	2 Points	1 Point	0 Points
Claim	Makes an accurate and complete statement linking independent and dependent variables	Makes an accurate but incomplete claim addressing only one variable	Makes an inaccurate claim	Does not make a claim
Evidence	Provided appropriate and sufficient evidence to support claim using qualitative and quantitative observations of both the independent and dependent variables	Provide appropriate but insufficient evidence to support claim	Provides inappropriate evidence. The evidence does not support the claim	Does not provide evidence
Reasoning	Provides reasoning that connects each piece of evidence to the claim. Uses scientific principles to explain why the evidence supports the claim.	Provides appropriate but incomplete reasoning. Each piece of evidence is not supported by a line of reasoning.	Provides inappropriate reasoning.	Does not provide reasoning.
Total				

Student Name: Date: Period:

C-E-R Rubric

Description	3 Points	2 Points	1 Point	0 Points
Claim	Makes an accurate and complete statement linking independent and dependent variables	Makes an accurate but incomplete claim addressing only one variable	Makes an inaccurate claim	Does not make a claim
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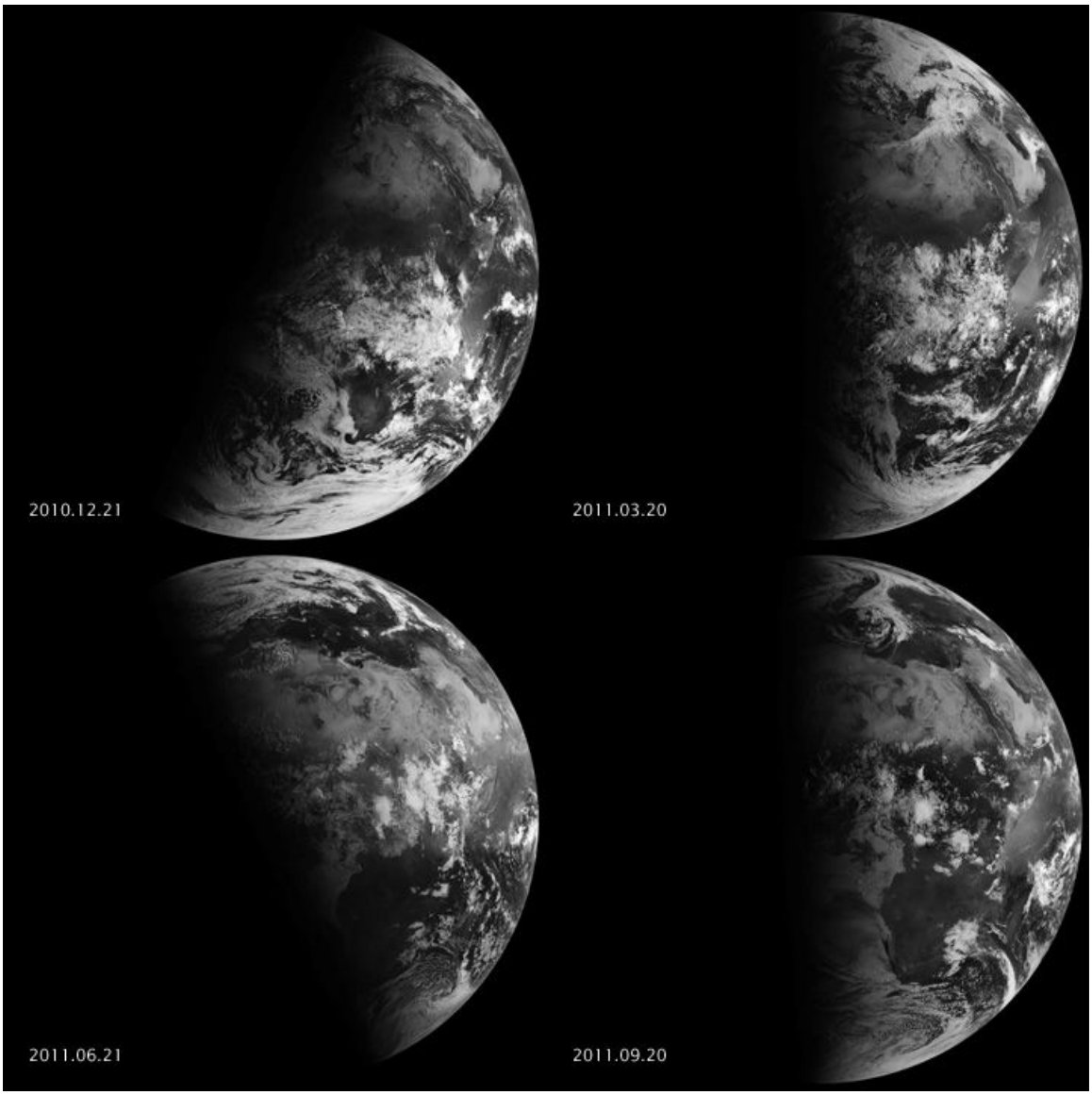
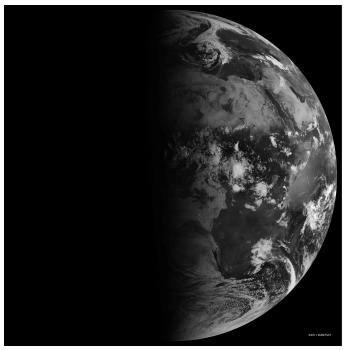
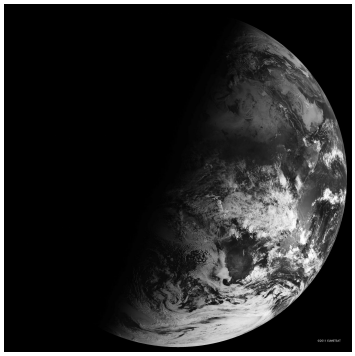
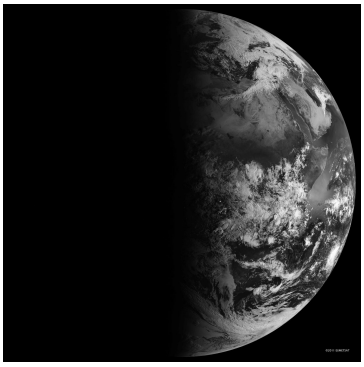
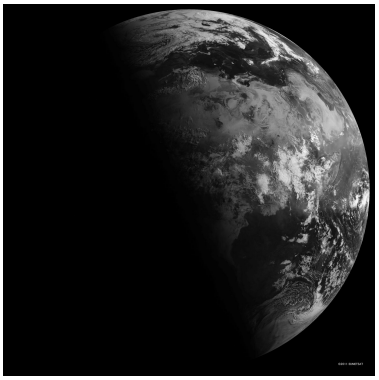
Total				


2010.12.21
2011.03.20
2011.06.21
2011.09.20

Satellite Views of Earth
Teacher Sheet

	On the September equinox (9/22), the terminator is a north-south line, and the sun is said to sit directly above the equator. Day and night are each approximately 12 hours long in both hemispheres.
	On the December solstice (12/21), the sun sits above the Tropic of Capricorn, shining more light on the Southern Hemisphere and giving this hemisphere longest “day” of the calendar year. The Northern Hemisphere has the “shortest” day of the year.
	On the March equinox (3/20), the terminator is a north-south line once again. Day and night are each approximately 12 hours long in both hemispheres.
	On the June solstice (6/21), the sun sits above the Tropic of Cancer, casting more light on the Northern Hemisphere and giving this hemisphere longest “day” of the calendar year, and the shortest “day” in the Southern Hemisphere.

Student Data Sheet 1

Student Name: Date: Period:

Claim: *(One sentence statement that addresses the relationship between solar insolation and surface temperature.)*	
Evidence: Sufficient, Appropriate, and Observation-driven	**Reasoning** *(Why is this evidence important?)*
Student Data Sheet: A **1.** **2.** **3.** **Student Data Sheet: B** **1.** **2.** **3.** **Student Data Sheet: C** **1.** **2.** **3.**	**Student Data Sheet: A** **1.** **2.** **3.** **Student Data Sheet: B** **1.** **2.** **3.** **Student Data Sheet: C** **1.** **2.** **3.**

Student Data Sheet 1

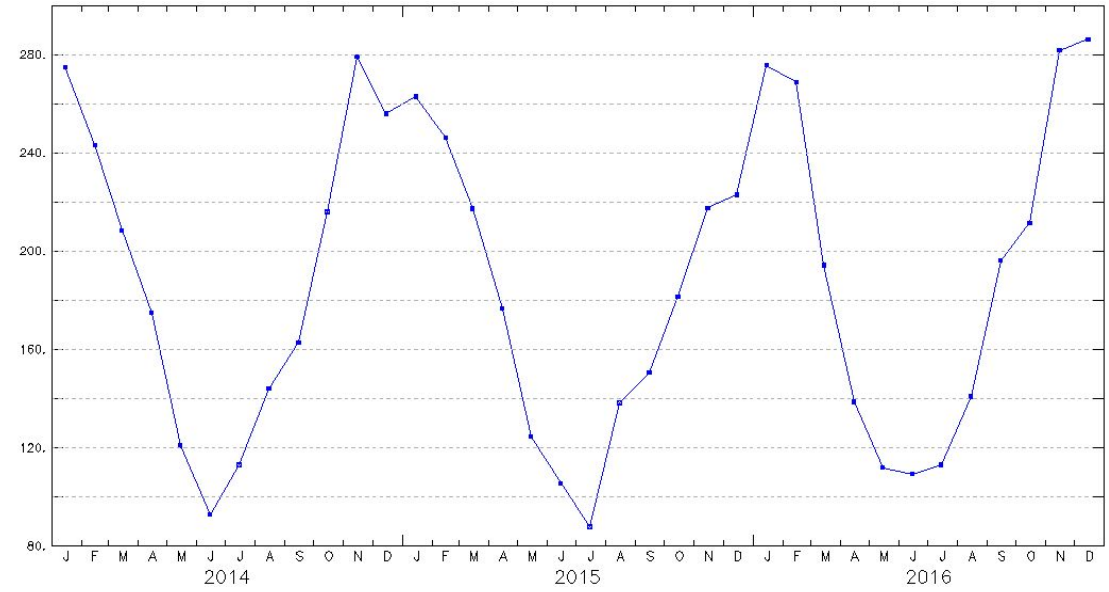
Student Name: Date: Period:

Claim: *(One sentence statement that addresses the relationship between solar insolation and surface temperature.)*	
Evidence: Sufficient, Appropriate, and Observation-driven	**Reasoning** *(Why is this evidence important?)*
Student Data Sheet: A **1.** **2.** **3.** **Student Data Sheet: B** **1.** **2.** **3.** **Student Data Sheet: C** **1.** **2.** **3.**	**Student Data Sheet: A** **1.** **2.** **3.** **Student Data Sheet: B** **1.** **2.** **3.** **Student Data Sheet: C** **1.** **2.** **3**

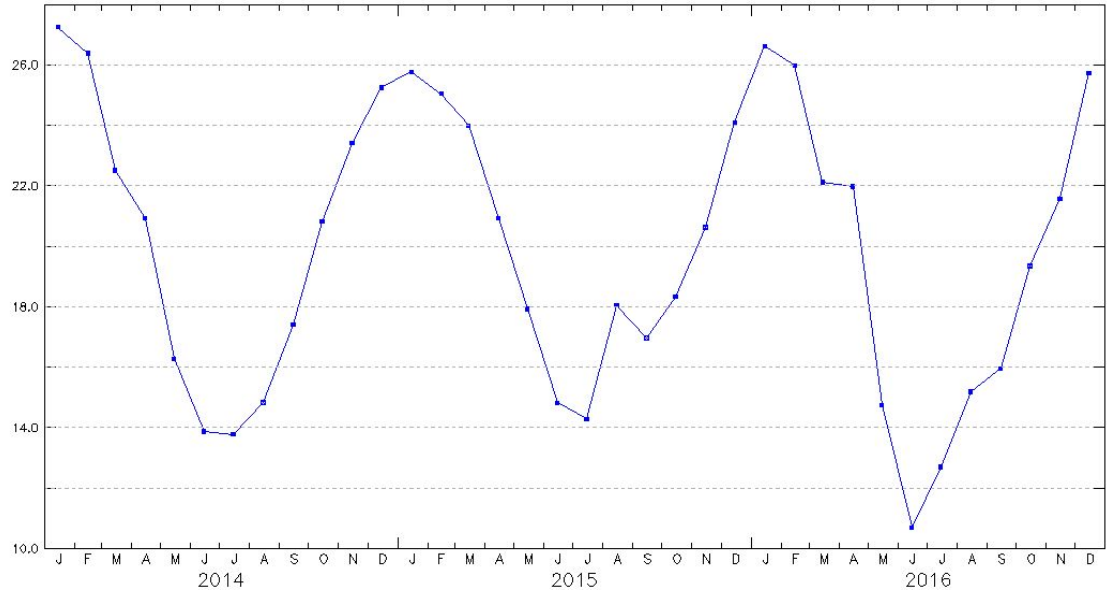
Student Data Sheet: A

Location: Porto Alegre, Brazil LONGITUDE : 51.5W(-51.5) LATITUDE : 30.5S

Surface Atmospheric Radiation, Monthly Surface (W/m^2)



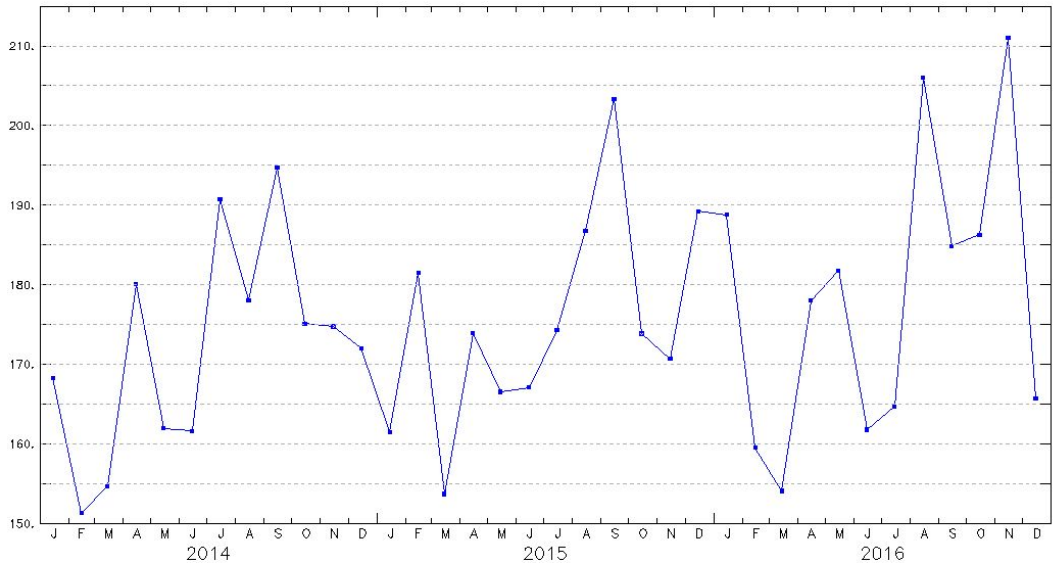
Surface Temperature, Monthly Surface (Celsius)



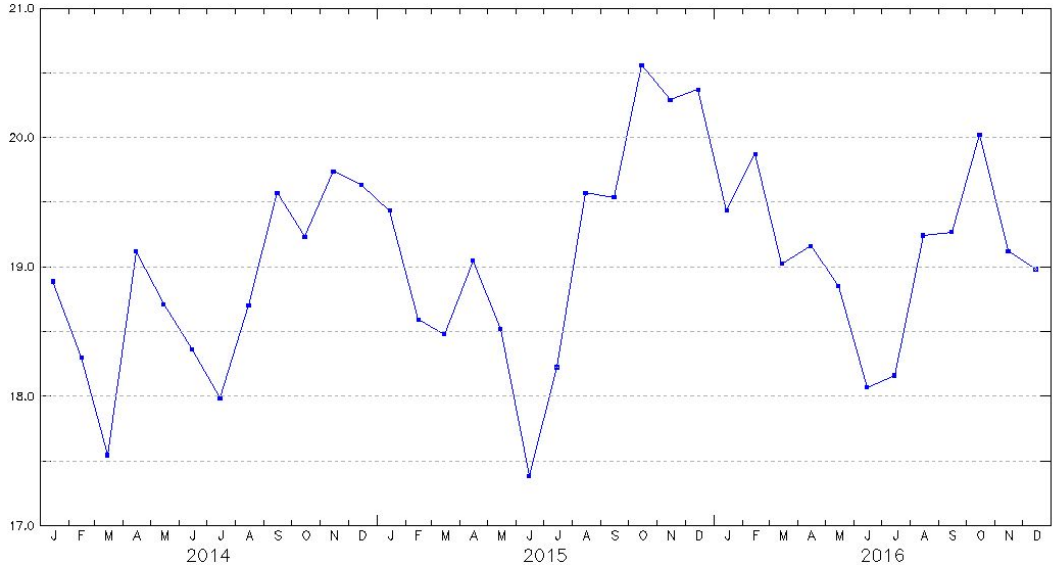
Student Data Sheet: B

Location: Quito, Ecuador LONGITUDE : 78.5 W LATITUDE : 0.5 S

Surface Atmospheric Radiation, Monthly Surface (W/m^2)



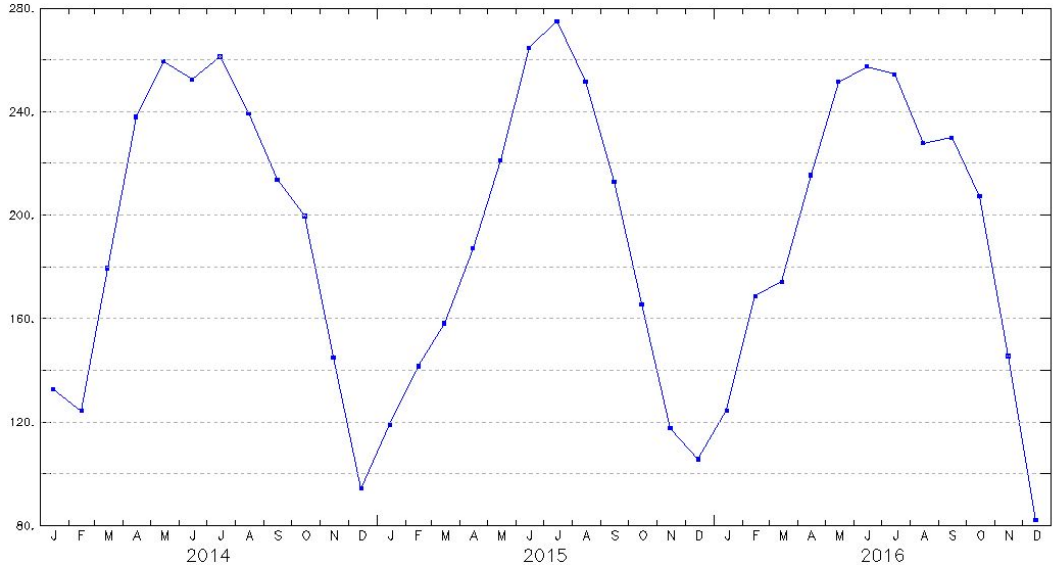
Surface Temperature, Monthly Surface (Celsius)



Student Data Sheet: C

Location: Memphis, TN LONGITUDE : 90.04W LATITUDE : 31.15 N

Surface Atmospheric Radiation, Monthly Surface (W/m^2)



Surface Temperature, Monthly Surface (Celsius)